# DigiCipher® II Multi-Channel Digital Television System

General Instrument

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## Introduction

Continuing a long tradition of innovation in television communications systems, General Instrument has been instrumental in creating the exciting new world of digital television. General Instrument's DigiCipher systems are propelling digital TV to new heights, including the widespread deployment of digital programming services to commercial affiliates and consumers on a worldwide basis. In addition, General Instrument's foresight is helping to foster advances in the emerging fields of HDTV, multimedia, and interactive television.

General Instrument's multi-channel DigiCipher system has become an international standard for efficient and secure distribution of high-quality digital programming services to cable systems and consumers. Production and commercial operation of General Instrument's DigiCipher I system, including Uplink Encoding System and Commercial Integrated Receiver/Decoder (IRD) products, commenced in 1992. DigiCipher I allows up to 10 television services to be digitally compressed and multiplexed for Multiple Channel Per Carrier transmission on a single satellite transponder.

The DigiCipher II system, with MPEG-2 compatibility, is designed with an open architecture to enable widespread use across a broad range of applications. This approach allows the system to be used over a long time-horizon, with evolutionary enhancements added as linkages are established between the television, computer, and telecommunications industries. While the initial application for DigiCipher II is to deliver digital television signals by satellite and cable to affiliates and subscribers, DigiCipher II signals are also transportable through microwave, fiber, and Asynchronous Transfer Mode (ATM) networks. In addition, the basic digital platform will ultimately be used for such applications as interactive television, multimedia, and HDTV.

# DigiCipher® II System Overview

DigiCipher II is an all-digital television system designed to digitize, compress, packetize, encrypt, multiplex, forward error correct, and modulate a number of NTSC, PAL, and/or SECAM television signals for transmission in a single satellite transponder. Digital audio, data, and text transmission are also supported. For satellite transmissions, DigiCipher II will be implemented in both Multiple Channels Per Carrier (MCPC or TDM) and Single Channel Per Carrier (SCPC or FDM) products.

With MCPC, all signals must be available at the Uplink Encoding System for multiplexing, Quadrature Phase Shift Keying (QPSK) modulation, and transmission on one carrier. MCPC maximizes the utilization of the transponder and allows the operator to transmit at full power. In addition, the statistical multiplexing feature of DigiCipher II can be used to continuously and dynamically allocate bandwidth to individual video services, optimizing the video quality across the various services sharing the MCPC bitstream.

The SCPC system allows diverse uplink sites to access a common satellite transponder. An offset QPSK modulation technique is used for SCPC, reducing the interference between the various SCPC carriers sharing a single transponder.

The DigiCipher II MCPC satellite signals can be downlinked to cable TV headends, processed (but not decompressed) by Integrated Receiver/Transcoders (IRTs), and then transmitted by Quadrature Amplitude Modulation (QAM) techniques through cable TV systems directly to cable subscribers (General Instrument's DigiCable™ System). In some DigiCipher II MCPC modes, the entire package of programming on a satellite transponder can be transcoded for carriage through a single 6, 7, or 8 MHz cable channel, using 64 QAM trellis-coded modulation. The IRT has an optional local access control interface to a cable TV addressable control system.

Alternatively, a single video service from a DigiCipher II MCPC satellite signal can be processed and decompressed by an Integrated Receiver/Decoder (IRD) in a cable headend, and then converted back to NTSC, PAL, or SECAM for analog transmission through a cable system. Similarly, DigiCipher II satellite signals can be received and displayed by C-band Television Receive Only (TVRO) and Ku-band Direct Broadcast Satellite (DBS) subscribers equipped with DigiCipher II Consumer IRDs.

## Summary of Major System Features

- Dual-mode video compression: DigiCipher® II and MPEG-2
- Carriage of NTSC, PAL, or SECAM signals
- Multiple video resolutions, including CCIR-601
- MPEG-2 transport format with fixed-length packets
- Dolby® AC-3 digital stereo audio
- Multiple MCPC transmission modes
- Statistical multiplexing of video services
- Modular encoder architecture with flexible redundancy
- Conditional access and encryption
- Consumer user interface
- TvPass™ Card renewable IRD security
- VideoCipher® II Plus backward-compatibility (decoder option)
- Virtual channels
- Flexible auxiliary data capacity
- Multilingual text services
- Closed captioning and VITS carriage and re-insertion
- Multiple SCPC bandwidths
- Network management software for subscription and Pay-Per-View (PPV) applications

## Product Functional Summary

**Uplink Encoding System**

- The encoder processes up to 24 D1 digital video signals or up to 16 analog video or non-D1 digital video signals. Inputs can be NTSC, PAL, SECAM, or component formats
- Processes audio signals, auxiliary data, and consumer authorization messages
- Digitally compresses video and audio signals
- Encrypts individual services and provides conditional access
- Formats service components into fixed-length transport packets
- Multiplexes digital video, digital audio, data, and control channel packets into a high-speed bitstream
- Implements coding for Forward Error Correction (FEC)
- Modulates bitstream on QPSK (Quadrature Phase Shift Key) carrier
- Outputs a frequency-agile signal at 70 MHz IF to external C-band or Ku-band satellite upconverter, or in the DS-3 format for remote modulation
- Interfaces to optional AMS (Affiliate Management System) and VCLINK™ software

- Includes an Uplink Control System (UCS) for all program and service control, Commercial IRD entitlement, encoder control and monitoring, and interface to commercially available program schedulers
- Includes I:J redundancy and multi-channel UCS computer to perform switching of redundant components in the event of a failure

**Commercial Integrated Receiver/Decoder (Commercial IRD)**

- Receives L-band QPSK satellite signal from LNB and tunes to the selected transponder
- Downconverts and demodulates bitstream from QPSK carrier
- Performs Forward Error Correction (FEC)
- Performs video and audio decompression for the selected television service
- Implements decryption/conditional access for selected television service and auxiliary data (if present)
- Provides analog composite NTSC, PAL, or SECAM television signal (and data, if present) for subsequent analog transmission through a cable or terrestrial television system
- In addition to single-channel Commercial IRDs, multi-pack IRDs are available for processing multiple DigiCipher II television services in one chassis

**Integrated Receiver/Transcoder (IRT)**

- Performs same front-end functions as Commercial IRD
- Implements FEC code for cable or terrestrial transmission
- Optionally performs decryption/re-encryption functions for local control
- Modulates QAM carrier for digital cable or terrestrial transmission within 6, 7 or 8 MHz bandwidth

**DigiCable™ Terminal**

- Receives, tunes, and demodulates desired digital QAM signal
- Performs forward error correction
- Performs video and audio decompression for the selected television service
- Implements decryption/conditional access for the selected service
- Implements advanced consumer interface for easy on-screen navigation
- Optionally includes Instant Pay-Per-View (IPPV) capability
- Provides analog composite NTSC, PAL, or SECAM television signal for viewing by the consumer

**Consumer IRD**

- Performs same front end functions as Commercial IRD
- Incorporates Instant Pay-Per-View and an advanced consumer interface

**Subscriber Authorization Center**

- Centralized national or regional computer center, equipped with General Instrument's Network Management System (NMS), Message Control

System (MCS), and Instant Pay-Per-View Management System (IMS) software

- The NMS processes subscriber authorization messages from multiple business systems
- The MCS produces a composite subscriber authorization stream for subscription and IPPV consumers, and transmits encrypted messages (addressed to individual consumers) to programmers' uplink sites for packetized insertion into DigiCipher® II Uplink Encoding Systems
- The IMS receives program scheduling and pricing information from IPPV programmers, manages the consumer IPPV credit/debit mechanism, and collects IPPV view histories from individual consumers, via telephone modem, for subsequent billing
- The Subscriber Authorization Center can be used to address home satellite consumers and/or cable subscribers

## Technology Highlights

### Digital Video Compression

DigiCipher II uses state-of-the-art digital video compression techniques based on motion-compensated Discrete Cosine Transform (DCT). DCT is a highly-effective coding technique, as validated by its adoption for the H.261, JPEG, and MPEG international standards. The DigiCipher II system implements dual-mode video compression: DigiCipher II and MPEG-2. The two modes are similar, with the DigiCipher II mode more optimized for television applications, including excellent video performance, quick channel acquisition, and low system end-to-end delay. The MPEG-2 mode includes B-frames to improve video quality at low bit rates, and allows potential interoperability with other services and consumer devices.

Many of the innovative compression techniques which have been implemented in DigiCipher I are carried forward into DigiCipher II:

- Film Mode
- Statistical Multiplexing
- Progressive Refresh
- Adaptive Field/Frame Coding
- Adaptive Inter/Intra Coding
- Error Concealment

In addition, the compression algorithm computes motion vectors based on half-pixel accuracy motion estimation and compensation. The bi-directionally predictive-coded motion technique (B-frames) is incorporated as an encoder option. All IRDs contain sufficient memory to process B-frames at half-resolution (352 horizontal pixels). Optionally, 8 Mbits of additional memory can be added to the IRD to allow full-resolution (704 horizontal pixels) capability with B-frames. Since B-frames add significant system end-to-end delay, channel acquisition delay, and IRD cost penalties, the DigiCipher II system is not dependent on B-frames and can produce excellent picture quality without their use, utilizing the DigiCipher II Adaptive Prediction Mode to dynamically optimize prediction on a field-mode or a frame-mode basis.

## Sampling Rate and Video Resolution

DigiCipher® II uses the CCIR-601 standard 13.5 MHz sampling rate. Chrominance is subsampled in accordance with the 4:2:0 MPEG-2 format.

The DigiCipher II system is capable of end-to-end processing and display of signals with the following luminance resolutions:

| 525 Line Countries | Horizontal Pixels Per Line | Active Video Lines |
|---|---|---|
| Full Resolution (CCIR-601) | 704 | 480 |
| 3/4 Resolution | 528 | 480 |
| 1/2 Resolution | 352 | 480 |
| 1/4 Resolution (Source Input Format) | 352 | 240 |
| **625 Line Countries** | **Horizontal Pixels Per Line** | **Active Video Lines** |
| Full Resolution (CCIR-601) | 704 | 576 |
| 3/4 Resolution | 528 | 576 |
| 1/2 Resolution | 352 | 576 |
| 1/4 Resolution (Source Input Format) | 352 | 288 |

## Packet Transport Structure

DigiCipher II employs the fully-packetized MPEG-2 transport structure. Fixed-length packets are used, whereby a given packet can represent video, audio, text, Vertical Interval Test Signals (VITS), synchronous data, asynchronous data, an authorization stream, service definition information, or program-descriptive information. The packet length is 188 bytes, including a four byte header, making it ATM-friendly. Other benefits of the DigiCipher II transport format include:

- Easy carriage through headend to cable subscribers
- Flexible service definition and virtual channel concepts
- Local insertion of advertisements or DigiCipher II television services from other transponders
- Mixable 525/60 and 625/50 video formats within the same multiplex

## Flexible Transmission Modes

With multiple forward error correction (FEC) rates and multiple QPSK/Offset QPSK symbol rate options, the DigiCipher II system enables programmers and operators to select from a variety of transmission modes, providing tradeoffs between information rate, coding gain, and required receive antenna size. IRDs are capable of automatically handling all of the modes at a given symbol rate. Some IRD models support multiple rates.

The DigiCipher II system utilizes powerful FEC techniques, based on concatenated convolutional and block (Reed-Solomon) codes, with interleaving. The following chart details the DigiCipher II MCPC and SCPC transmission modes. The system is being designed to support additional QPSK and OQPSK symbol rates and convolutional code rates.

| DigiCipher® II Transmission Modes | | | | |
|---|---|---|---|---|
| Symbol Rate | Occupied Bandwidth | FEC Rate (Convolutional) | Information Rate | Modulation Format |
| 29.3 MHz | 36 MHz | 1/2 | 27.0 Mbps | QPSK |
| 29.3 MHz | 36 MHz | 2/3 | 36.0 Mbps | QPSK |
| 29.3 MHz | 36 MHz | 3/4 | 40.5 Mbps | QPSK |
| 29.3 MHz | 36 MHz | 7/8 | 47.2 Mbps | QPSK |
| 19.5 MHz | 24 MHz | 1/2 | 18.0 Mbps | QPSK |
| 19.5 MHz | 24 MHz | 2/3 | 24.0 Mbps | QPSK |
| 19.5 MHz | 24 MHz | 3/4 | 27.0 Mbps | QPSK |
| 19.5 MHz | 24 MHz | 7/8 | 31.5 Mbps | QPSK |
| 14.6 MHz | 18 MHz | 3/4 | 20.2 Mbps | Offset QPSK |
| 14.6 MHz | 18 MHz | 7/8 | 23.6 Mbps | Offset QPSK |
| 9.76 MHz | 12 MHz | 3/4 | 13.5 Mbps | Offset QPSK |
| 9.76 MHz | 12 MHz | 7/8 | 15.7 Mbps | Offset QPSK |
| 4.88 MHz | 6 MHz | 3/4 | 6.7 Mbps | Offset QPSK |
| 4.88 MHz | 6 MHz | 7/8 | 7.9 Mbps | Offset QPSK |
| 3.25 MHz | 4 MHz | 3/4 | 4.5 Mbps | Offset QPSK |
| 3.25 MHz | 4 MHz | 7/8 | 5.2 Mbps | Offset QPSK |

For cable applications, a subset of these modes may be directly remodulated using 64 QAM. FEC specific to the cable application is applied in the form of concatenated trellis coding and Reed-Solomon coding, with interleaving.

## Multiplexing Modes

DigiCipher II employs statistical multiplexing between video streams in an MCPC encoder, providing higher quality and more consistent video relative to a fixed bandwidth system. The system also supports limited statistical multiplexing in which the bit rate of any designated video stream cannot fall below a programmable threshold, and fixed rate multiplexing in which a video stream operates at a fixed data rate. All modes may be mixed within a single transport multiplex.

While there are multiple information rate options in DigiCipher II, for information rates of 30 Mbps or lower, the "I" and "Q" components of the QPSK bitstream can be processed together as a single multiplex, allowing statistical multiplexing across all television services sharing the transponder. For information rates higher than 30 Mbps, there is an independent split between I and Q components. For these split modes, statistical multiplexing only occurs among television services sharing the I or Q side of the multiplex.

By mixing modes, some streams within a multiplex can be set to operate at fixed bit rates, while other channels can be statistically multiplexed. Thus, in a six-channel encoder, one channel could be set to operate at 8 Mbps, while the other five channels could be statistically multiplexed together, sharing the remaining video bandwidth.

## Conditional Access and Encryption

DigiCipher® II conditional access and encryption is based on General Instrument's network control software, the Data Encryption Standard (DES) encryption algorithm, a multi-level key hierarchy, and secure hardware and firmware implementations in the IRD. IRDs have renewable security interfaces, whereby security can be enhanced by inserting a new, user-installed security element (TvPass™ Card) into the IRD. Fully encrypted, fixed key, and unscrambled encryption modes are supported on a service-by-service basis.

Data channels can be encrypted independently or with the same keystream as a television service. For applications operating outside the U.S. and Canada, auxiliary data channels are transmitted in the clear (non-encrypted).

Tier bits are used for differentiating services or groups of services via the conditional access system. A single tier bit can be assigned to one program, one service, or to a group of programs or services. The system supports a tier space of approximately 65,000 tier bits. Initial IRDs will support 512 tier bits.

The DigiCipher II system uses the flexible transport packet mechanism for distributing authorization streams, program-descriptive information, and service definition information. The bandwidth of the DigiCipher II authorization stream can fluctuate depending on the subscriber population and the desired rate of distributing conditional access messages.

General Instrument's Authorization Center software, which has been developed and continually enhanced by General Instrument over the last decade, is used for authorizing DigiCipher II Consumer IRDs for the TVRO/DBS markets. General Instrument's multi-channel Uplink Control System (UCS) software complements the conditional access functionality of the Subscriber Authorization Center, and is used primarily for commercial affiliate authorization and program-specific functions such as program-related key distribution, program titles, and IPPV event prices.

General Instrument's optional Affiliate Management System (AMS) provides the ability to group Commercial IRDs for purposes such as efficient authorization/de-authorization and automatic retune. The AMS interfaces to the UCS. The Uplink Encoding System also supports connectivity to a non-General Instrument affiliate management system through General Instrument's optional VCLINK™ software.

## Encoder Redundancy and Modular Architecture

The DigiCipher II encoder can be contained within a single rack measuring 19" wide and 28" deep. Rack height varies depending on the configuration selected (i.e., number of television services, optional format conversion, etc.). The rack may contain up to three encoder enclosures, each measuring 24.5" high and providing capacity for compressing, multiplexing, and modulating up to eight D1 digital television services. NTSC, PAL, and/or SECAM services can be mixed within a single encoder. A fully configured DigiCipher II encoder rack contains three enclosures and measures 78" in height. The capacity of this configuration is 24 D1 (serial digital component video inputs with embedded audio SMPTE-125M/SMPTE-259M) television services or 16 television services for non-D1 source material. Programmers will likely choose to utilize some of this capacity for redundancy.

The encoder accepts D1 for both NTSC, PAL, and SECAM formats. Other SMPTE standards such as D2 and D3 digital composite video are supported through optional standards converters. In addition, the converters accept composite analog video and component (Y, C) analog video inputs, converting these inputs to D1 digital video format. Analog audio inputs are also converted to D1 embedded audio by the standards converters.

The encoder employs an I:J redundancy approach, in which a variable number ("I" = 0, 1, 2) of spare sets of video/audio compression cards are used to backup "J" television services. Since a single digital encoder enclosure can house circuit cards for up to eight digital television channels, the programmer can select, for example, "0 for 8," "1 for 7," "2 for 6," or "1 for 1" (i.e., "4 for 4") redundancy. 1:1 redundancy is provided for other encoder functions such as packet multiplexing, FEC, QPSK modulation, and the encoder enclosure power supply.

In the basic configuration, two stereo audio pairs, one synchronous data channel, and one asynchronous data channel are available per television service. Thus, up to eight television services, 16 digital audio stereo pairs, eight synchronous data channels, and eight asynchronous data channels can be processed in a single encoder enclosure.

The DigiCipher® II encoder is designed to allow removal and replacement of circuit cards with power on (hot swap). The redundant encoder power supply also supports hot swap.

## Other System Features

### Virtual Channels

The DigiCipher II system supports "virtual channels," a feature which decouples actual services (e.g., video and associated audio) from satellite transponders or cable channels. Instead of requiring the consumer to rely on satellite names and transponders, virtual channels allow mapping of virtual channel numbers to specific services. For example, a given sports channel with English audio might correspond to virtual channel number 50, while the same sports channel (same DigiCipher II satellite feed) with Spanish audio might correspond to virtual channel number 51.

The mapping between a virtual channel number and the corresponding service is done at either the Subscriber Authorization Center or the UCS. The virtual channel maps are then downloaded to satellite IRDs or DigiCable™ terminals.

### Audio Channels

The DigiCipher II system supports Dolby® AC-3 digital stereo audio technology. Dolby AC-3 is a state-of-the-art digital audio system, allowing ultimate migration to multi-channel digital surround sound. The initial encoders and IRDs will implement stereo AC-3. If Surround AC-3 (5.1 channels) is implemented in the future, these IRDs will be capable of extracting a high-quality stereo signal from the 5.1 channel Surround AC-3 signal. A 5.1 channel audio surround system refers to left, right, center, and two surround channels, plus an additional low-frequency enhancement channel.

The DigiCipher II audio sampling rate is 48 kHz or 44.1 kHz, corresponding to industry standard interfaces. Two stereo pairs (four audio channels) will be allocated to each television service as a basic capability. Additional audio channels may also be allocated. The bandwidth corresponding to any unused audio channels may be allocated to the video streams.

Stereo AC-3 (two channels) can be transmitted at 128 kbps or 192 kbps. In general, the 192 kbps stereo AC-3 signal is equivalent in subjective quality to CD stereo audio.

## Consumer User Interface

The advanced, graphical consumer interface empowers consumers with the ability to personalize and manage the increased channel capacity that DigiCipher® II offers. The features of the consumer user interface consist of an electronic program guide, near video on demand, and interactive applications.

## Electronic Program Guide

The General Instrument DigiCipher II product line features a flexible, easy-to-use, interactive program guide designed to promote programming, increase awareness and reduce complexity associated with increased channel capacity. The interactive program guide provides a navigation environment, viewing controls and on-line services to the consumer. The interactive environment allows for future downloadable services and applications without necessitating hardware or software changes.

## Auxiliary Data Channels

The DigiCipher II system accommodates asynchronous and synchronous data channels. Asynchronous data channels can operate at discrete rates of 1200, 2400, 4800, 9600, or 19,200 baud. Synchronous data channels can operate at discrete rates from 19.2 kbps to approximately 2 Mbps. While the flexible transport structure allows carriage of virtually any combination of data channels at the various rates, the basic encoder design allows one asynchronous data channel and one synchronous data channel per television service. If the user decides not to utilize auxiliary data channels, the unused information bits may be allocated to the video streams.

## Closed Captioning

DigiCipher II supports carriage and IRD re-insertion of closed caption information in both field 1 and field 2 of line 21. According to FCC rules, line 21, field 2 may be used for enhanced closed captioning and other broadcast-related information, such as Extended Data Service (EDS).

## Pay-Per-View

The system supports Instant Pay-Per-View (IPPV), based on store-and-forward technology. DigiCipher consumer products (Consumer IRDs, DigiCable™ Terminals) may optionally contain integral IPPV modems for periodically forwarding view history information, via telephone return path, to a centralized Authorization Center. Call-ahead PPV is also supported, whereby the consumer must make a telephone call in advance of a specific event to order and be authorized for the event.

## Copy-Protection Capability

The DigiCipher II system provides Macrovision copy-protection capability for potential use in consumer PPV applications. The Macrovision PPV copy-protection process involves inserting pseudo-sync and AGC pulses in certain VBI lines, as well as inverting the color burst to cause color stripes on a recorded output.

### VideoCipher® II Plus Compatibility

For the North American C-band market, DigiCipher® II Commercial and Consumer IRDs are capable of decoding both DigiCipher II and VideoCipher® II Plus signals (as well as clear FM NTSC signals). This feature is important due to the large amount of programming encrypted in the VideoCipher II Plus format.

### Text Capability

DigiCipher II supports a broad range of multilingual text services including user screens, program guides, program names, service names, virtual channel names, personal messages, tier-addressed messages, subtitles, and teletext-like information services.

### Parental Rating Control

Parental Rating Control allows the subscriber to set a certain rating control threshold, based on programmer-supplied ratings. Programs rated above the threshold cannot be viewed without overriding the setting or changing the threshold via password.

### Program Blackouts

Three types of consumer blackouts are supported: circular blackouts, spotbeam blackouts, and regional blackouts. Circular blackouts are based on postal code information and allow up to 56 different blackout circles. Spotbeam blackouts are the reverse of circular blackouts; instead of all Consumer IRDs in a postal code-based circular area being blacked-out, all Consumer IRDs not in a specified circular area or areas are blacked-out. Regional blackouts can be used for blacking out IRDs in a particular state, province, or country.

### 16:9 Aspect Ratio

The DigiCipher II system has inherent capability to support 16:9 aspect ratio signals. If source material is supplied as a 16:9 image, the Uplink Encoding System will digitally sample, compress, and transmit the 16:9 information. A DigiCipher II IRD will decompress and display the image either in the 16:9 or 4:3 format, depending on the consumer's TV set format. For display on 4:3 TV sets, pan information must be conveyed from the source material to the Uplink Encoding System, and then to the IRD.

### Diagnostic Screens

The DigiCipher II Commercial and Consumer IRDs support On-Screen Display (OSD) diagnostic screens for displaying information relating to such items as signal quality, authorization status, and geographic location. The diagnostic OSD is important for installation and troubleshooting.

### Commercial IRD Retune

The DigiCipher II system supports automatic retune of Commercial IRDs, whereby a designated group of Commercial IRDs can be commanded by satellite-delivered messages from the UCS to tune to a different DigiCipher service. The retune can occur within a transponder (i.e., same DigiCipher multiplex), to a DigiCipher service on another transponder on the same satellite, or, subject to L-band input hardware limitations, to DigiCipher services on one or more other satellites.

### Vertical Interval Test Signals

DigiCipher® II supports the carriage and IRD re-insertion of VITS information. If VITS is not present, the bandwidth is automatically allocated to video services.

## Conclusion

The DigiCipher II system is extremely robust, flexible, and comprehensive, meeting the long-term needs of programmers, cable operators, broadcasters, cable subscribers, home satellite consumers, and business and educational users. It builds on General Instrument's considerable experience with DigiCipher I in developing and fielding digital compression television systems. It uses a dual-mode video compression algorithm, based on MPEG-2 syntax. The ATM-friendly, MPEG-2 fixed-length packet transport format allows carriage of NTSC, PAL, and SECAM digital television signals, along with other digital data, within a multiplex. General Instrument's state-of-the-art conditional access system is used for secure delivery and management of subscription and PPV programming. Finally, many important consumer and commercial features are included, resulting from many valuable customer inputs and General Instrument's expertise in designing and deploying television communications systems.

## DigiCipher® II System Capabilities

| | |
|---|---|
| **Image Array** | |
| › Horizontal | 704; 528; 352 pixels |
| › Vertical | 576; 480; 288; 240 lines |
| **Video Compression** | Dual Mode: DigiCipher II; MPEG-2 |
| **TV Signal Formats** | NTSC; PAL; SECAM |
| **Chrominance Subsampling** | 4:2:0 |
| **Modulation** | |
| › Satellite | QPSK (MCPC); Offset QPSK (SCPC) |
| › Cable | 64 QAM |
| **Forward Error Correction** | |
| › Satellite | Multi-Rate Concatenated Convolutional/R-S Code |
| › Cable | Concatenated Trellis/R-S Code |
| **Multiplexing** | Statistical; Limited Statistical; Fixed Rate; Mixed |
| **Transport** | MPEG-2 Fixed-Length Packets (188 bytes) |
| **TV Services per carrier** | |
| › MCPC | 24 D1 digital video signals or 16 non-D1 digital or analog video signals |
| › SCPC | 1 video signal per carrier |
| **Audio Channels** | 4 audio channels per TV service |
| **Audio Compression** | Dolby® AC-3 digital stereo |
| **Auxiliary Data Channels** | One 2.4, 4.8, 9.6, or 19.2 kbps Asynchronous and one 19.2 kbps to 2 Mbps Synchronous Data Service per television service for the basic Encoder design (Flexible combinations available) |
| **Conditional Access** | General Instrument<br>- Multi-Level Key Hierarchy<br>- DES Encryption for Video and Audio<br>- Renewable Security (TvPass™ Card)<br>- Support of Subscription and PPV Programs |
| **Copy-Protection** | Macrovision* |

*The Macrovision process is licensed for non-commercial, home use only, for potential consumer pay-per-view applications. For actual use of the Macrovision process, programmers or system operators must be authorized by Macrovision Corporation.

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